SEDIMENT ENGINEERING THRU DREDGING AND WITH NATURE (SETDWN) – FATE OF FINES IN THE DREDGING AND PLACEMENT PROCESS

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Abstract: The SETDWN initiative is positioned to develop a better understanding of sediment behavior and losses throughout the dredging and placement process. Present regulation bases beneficial use options for dredged material on the in-situ fine fraction, However, evidence indicates that a significant amount of these fines are released during the dredging process and are not present at the placement site. Empirically determining the percentage of fines lost between the dredge intake and final placement on the beach or in the littoral zone as a function of the dredge equipment and construction method and is intended to provide justification for a fundamental shift in the current overly conservative regulatory approach to a more engineered actual risk based set of permit requirements.

Introduction

The Sediment engineering thru dredging and with nature (SETDWN) (previously referred to as the Ship to Shore or Fate of Fines) research objective is to develop a better understanding of the changes in sediment characteristics and material loss throughout the dredging and placement process. Empirically determining the percentage of fines (fine sediment less than 63 microns) lost between the dredge intake and final placement on the beach as a function of the dredging equipment and construction methodology will provide justification for a fundamental shift in the current conservative regulatory approach to a risk-based engineering approach defining achievable, consistent and quantitative permit requirements. Understanding the behavior and long term fate of fine material provides an opportunity to better manage valuable sand resources while not endangering the environmental resources. Such data may reduce the need for expansion of Offshore Dredge Material Disposal Sites (ODMDS) and the creation of additional upland Confined Disposal Facilities (CDF's) or Dredge Material Management Areas (DMMA's). Results of this study are not only

important to meeting Regional Sediment Management (RSM) goals, but in providing empirical information quantifying the sorting of sediment during dredging processes and the natural sorting of placed sediment, which is fundamental to increasing Engineering With Nature (EWN) opportunities in dredged material management.

Purpose

Regulatory Agencies typically set threshold criteria required for the use of dredged material from navigation channels. For example, the Florida Department of Environmental Protection (FDEP) requires that for navigation dredging projects, a maximum of 10% fines passing the #230 U.S. Standard sieve (63 microns) as measured in the channel is allowed for beach placement and 20% fines is allowed for nearshore placement. From a dredging operations and beach construction perspective, material is lost and a significant percent of fines is winnowed during the dredging and placement process.

In the absence of accurately predicting the percentage of fines lost through the dredging process, regulatory agencies normally take an approach that is "zero risk" by using the conservative assumption that no loss of fine material occurs during the dredging process from the borrow site to the placement site. This conservative assumption often completely eliminates the opportunity to beneficially use material dredged from navigation channels. This results in dredged material being placed in offshore or upland disposal areas and directly limits the amount of sediment retained in the natural coastal system.

The goal of this study is to determine the percentage of fine material reduction that occurs throughout the dredging process for various methodologies and equipment. This should allow for projects to be planned, permitted and designed while taking into account desired or required the final grain size characteristics ultimately resulting in less costly to construct beach projects and increasing the beneficial use of dredged materials.

Allowing for a more informed interpretation and application of the Sand Rule based upon a robust estimate of a reduction of fine sediments will save U.S. Army Corps of Engineers(USACE) Operations and Maintenance (O&M) dollars by opening up placement areas close to shore and will fulfill the RSM principle of retaining sand to the littoral zone.

Methods

Field samples were collected of the dredge inflow, overflow, beach discharge, carrier return water, and the beach berm at numerous project sites. These

projects were typically sampled over several days to obtain average loss percentages of fines throughout each stage of the dredging process. Suitable additional field sites are being added around the country as they are identified and logistics worked out with the individual project management teams.

Beach Sampling

The material discharged at the beach weather it is from a hopper pumpout, cuttersuction, or hydraulic offloader; experiences similar winnowing processes. The beach discharge slurry contains the full spectrum of material grain sizes entrained by the dredge/pump. The return water making it to the active swash zone primarily contains a relatively fine fraction of material

To date intensive physical sampling of discharge operations have been conducted at Jupiter Inlet, Delray Beach, St Lucie Inlet, and Egmont Key, Florida.

Figure 1. Sample collection of discharge slurry at Jupiter Inlet, Florida, February 2014.

Figure 2. Offshore borrow material placed on Delray Beach, Florida, February 2014.

Figure 3. St. Lucie Inlet dredging beach discharge slurry, February 2014.

Figure 4. St. Lucie Inlet dredging return water flowing into the swash zone transporting fine sediments, February 2014.

Figure 5. Egmont Key placement of dredged material from Tampa Harbor, December 2014.

Hopper Dredge Sampling

The inflow (discharge into the hopper) contains a slurry of the full spectrum of material grain sizes entrained by the dredge drag arms. The hopper overflow return water contains a relatively fine fraction of material. The loss of this material in the overflow results in a coarsening of the dredge load. Collecting samples at each of these points throughout a loading event allows for the determination of the approximate grain size and quantity of the fine material lost during this process. The loss of this finer material in the overflow results in an overall coarsening of the material being pumped to the beach.

The hopper dredge sampling methodology is for determining exactly where, during the dredge process, fines are lost and to approximate the amount of loss at each specific dredge process stage. The methods include collecting numerous samples of intake and pump-out material at a wide variety of locations and aboard various dredge types. This data will be used to empirically estimate the reduction in fines as a function of the amount of fines in situ and dredge type. To date only the USACE special purpose dredge the Murden has been intensively sampled, while dredging the Gulf Intracoastal Waterway (GIWW) in Cortez, Florida.

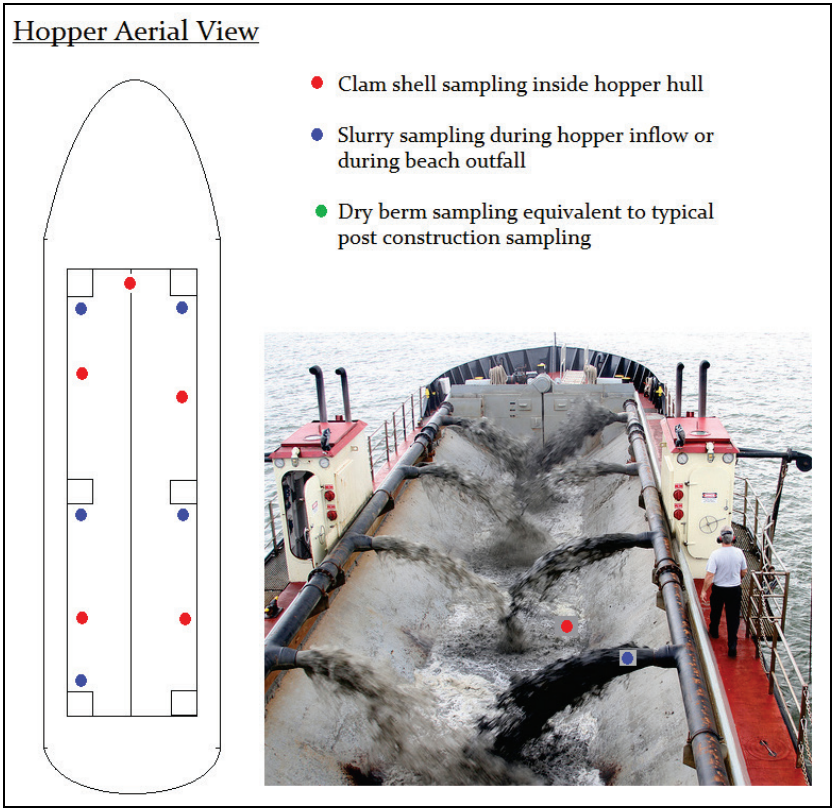

Figure 6. Hopper dredge process sampling methodologies developed and employed.

Initial Results

A comparison of pre-fill sediment characteristics from the historic compatibility/quality assurance plan and post-fill sediment characteristics from the compatibility analysis were used to empirically estimate the loss of fines during historical beach placement projects. This study analyzes historical projects from the previous 20 years from both the U.S. Army Corps of Engineers and FDEP databases.

Table 1. SAND Study (Table 6. compatibility data for projects showing the borrow source and post-fill composite statistics; Ousley et al., 2014).

Project/Year	Fill Volume	Sediment Source	Source Composite Stats			Post-fill Beach Composite Stats		
			Mean mm	Sorting phi	% passing #230	Mean mm	Sorting phi	% passing #230
Duval SPP, 2005	710,000 cy	Duval B/A "Area A"	0.25	1.15	3.4	0.25	0.85	0.70
Tampa Harbor O&M, Egmont Key, 2005	1.3 mcy	Egmont Channel and Mullet Key Cut	0.35	1.58	25	0.27	1.21	2.5
Ft. Pierce SPP, 2007	517,000 cy	Capron Shoal	0.43	0.97	1.6	0.60	1.34	0.10
IWW O&M, St. Augustine Inlet, 2008	122,648 cy	IWW, St. Augustine Inlet	0.28	1.94	2.57	0.28	0.84	0.41
Lee Co. SPP, Captiva Island, 2008	98,270 cy	Borrow Site VI	0.40	1.04	0.87	0.51	1.34	0.53
IWW, Matanzas Inlet, 2009	288,647 cy	IWW, Matanzas Inlet	0.16	0.64	3.15	0.24	0.42	0.29
John's Pass O&M, 2010	250,000 cy	John's Pass Entrance Channel, Shoal east of channel	0.24, 0.16	0.73, 0.56	0.86, 1.69	0.22	1.07	0.21
Treasure Is./Long Key SPP, 2010	160,000 cy	Blind Pass Entrance Channel	0.24	1.59	1.71	0.18	0.89	0.21
Duval SPP, 2011	689,015 cy	Duval B/A "A + A2"	0.17-0.26	-	1.70	0.25	0.87	1.18
IWW O&M, Bakers Haulover Inlet, 2011	33,000 cy	IWW, Bakers Haulover Inlet	0.26	1.30	6.48	0.67	0.72	0.20
Sand Key SPP, 2012	1.2 mcy	Borrow Area L	0.18	0.96	3.04	0.28	1.37	0.58

SPP: Shore Protection Project; B/A: Borrow Area; O&M: Operation and Maintenance; IWW: Intracoastal Waterway; cy: cubic yards; mcy: million cubic yards

The 2014 Southeast Florida Sediment Assessment and Needs Determination (SAND) Study included a review of fines lost during dredging by comparing composite in situ sediment data and post construction composite sediment data. It is observed that in all cases fines were lost during the dredging process (Ousley et al., 2014).

New field data collected in 2014 will be available in the final paper. The results of the historical and field data indicated that a significant loss of the initial fine fraction occurs during the dredging and placement process.

Conclusions

This study includes data from around the state of Florida and is being expanded throughout the United States. The findings will be applicable to most O&M and shore protection projects. This research effort could change our sediment management strategy by maintaining a greater mass of sediment in the littoral zone instead of offshore or in upland placement and saves money due to decreased pumping and transit distances.

The SETDWN initiative is to empirically quantify of the amount of fines lost during dredging and placement events thru time may justify an expanded variance of material that can be placed for beneficial use. Thus, this would maximize the materials retained in the littoral system and eliminate the irreversible loss of littoral sediment that is deemed “marginal” while providing reasonable assurance to regulating agencies of compliance with in situ percent fines criteria. This same process can be employed for the winnowing of other constituents in mixed sediments as well.

Demonstrating this coarsening as a percentage of the fine fraction lost at each stage of a project should allow for a re-analysis of conservative regulatory assumptions and permit variances based on sound science.

Acknowledgments

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